Correspondence

COMMENTS ON "FORMATION AND STEERING MECHANISMS OF TORNADO CYCLONES AND ASSOCIATED HOOK ECHOES"

KEITH A. BROWNING
Air Force Cambridge Research Laboratories, Sudbury, Mass.

In part of a recent article, Tetsuya Fujita [3] describes the three-dimensional structure of severe local storms as observed by radar. He points out, for example, that, while a hook echo at low levels is situated on the right rear flank of the main echo area, the hook is located beneath the center of the major cell between the 30,000- and 40,000-ft. levels. He also draws attention to an echo-free eye which extends upward from the hook echo directly beneath the storm's highest top. This is precisely the kind of structure which I have described in a recent paper (Browning [1]).[1] In this paper I accounted for the storm structure in a somewhat different manner from Fujita, and therefore I feel that a comparison of our two explanations is in order. Although Fujita introduces some dynamical notions into his treatment, I shall restrict myself to a consideration of the kinematics of the severe local storm.

1. Fujita and I are in agreement that an intense updraft ascends within and around the echo-free eye and that the central portion of this updraft is more or less echo-free because of the inadequate time for cloud droplets to grow to radar-detectable sizes. However, there is of course the additional factor that the central portion of the updraft must be sufficiently intense to inhibit the re-entry of even the largest hydrometeors growing on its periphery.

Since the eye as seen by radar evidently is produced in a different manner from the hurricane eye, it is better to give it a different name. In severe local storms the eye is limited in the vertical by a ceiling of intense echo, and so I have been using the term "vault" to describe it.

2. At low levels the hook echo appears as an appendage on the right rear flank of a larger echo (fig. 1). Fujita, in common with many radar meteorologists, calls the larger echo the "major thunderstorm cell"; sometimes it is called the "parent" or "mother" echo. Fujita apparently attributes it to a second region of updrafts, in which the vertical velocities are weak compared to those in and around the vault. In my view, however, the so-called major thunderstorm cell is predominantly

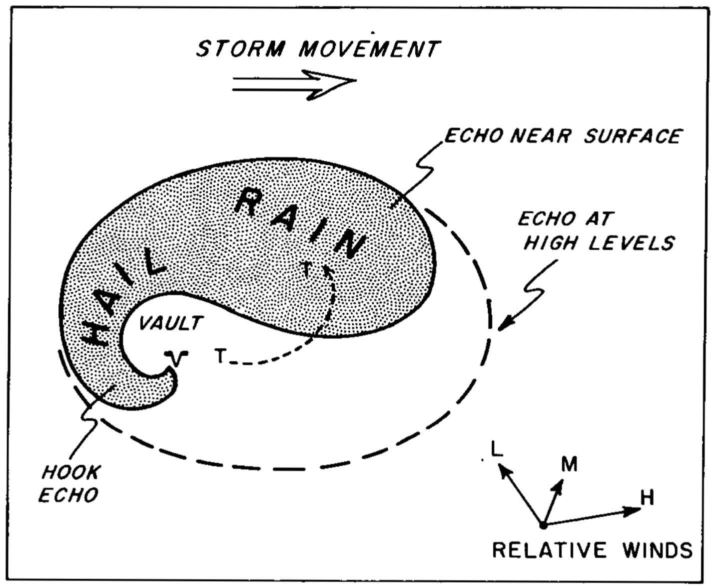

FIGURE 1.—Schematic diagram showing the radar structure of a severe local storm at low and high levels (as seen, for example, at 20 mi. range by a WSR-57 radar with 20 to 30 db. of gain reduction). The echo-free region, labeled vault, extends upward more or less vertically beneath the storm's highest top. The rain area, sometimes called the major thunderstorm cell, is believed to be due to precipitation particles descending along trajectories like TT after being released from the summit of an intense updraft ascending in and around the echo-free vault. Environmental winds relative to the storm at low, medium, and high levels are represented by the three vectors, L, M, and H. (Adapted from figs. 3 and 5 of Browning [1].)

a region of downdrafts associated with precipitation falling more or less passively after being released from near the summit of the primary updraft directly above the vault. Because the environmental winds relative to an eastward-moving severe storm are generally from the west at high levels and from the south at low levels, these particles descend ahead of the vault region and then turn toward the left forward flank at lower levels (along trajectories like TT in fig. 1) to give an over-

[1] A preliminary version of this paper was presented at the Third Conference on Severe Local Storms, Urbana, Ill., November 1963.